Job Analysis: Embedded Software Engineer in the USA

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Basic Overview

Embedded Software Engineers (ESEs) specialize in developing and maintaining software for embedded systems found in devices like smartwatches, cameras, UAVs, ADAS, Wi-Fi routers, etc. They are vital for organizations aiming to incorporate intelligent systems into their products.

Unlike traditional software engineers, ESEs focus on specific hardware platforms with resource constraints and real-time demands. This requires them to possess hardware knowledge for collaboration with Embedded Hardware Engineers (EHEs), raising the entry threshold but fostering career longevity.
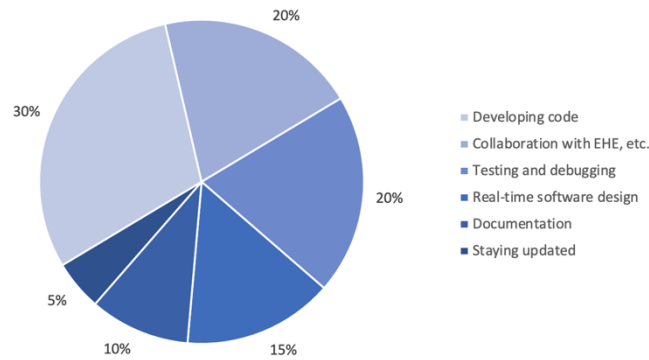
EHEs and ESEs serve as architects and designers for embedded systems. EHEs establish physical platforms, enabling ESEs to integrate operating systems and functionality, effectively managing hardware components to meet consumer needs. ESEs are often categorized into embedded driver engineers and embedded application engineers, with recruitment KSAOs remaining largely consistent. Before delving into ESEs' KSAOs, we'll clarify their essential duties and corresponding importance within embedded software engineering.

Position Description and KSAOs

Embedded Software Engineers (ESEs) are responsible for developing software tailored to specific embedded systems, aligning with hardware specifications and consumer requirements. Their core mission encompasses designing, developing, maintaining, and optimizing software to enable the functionality of various products. In their workflow, ESEs stay updated on team progress and collaborate with cross-functional engineers.
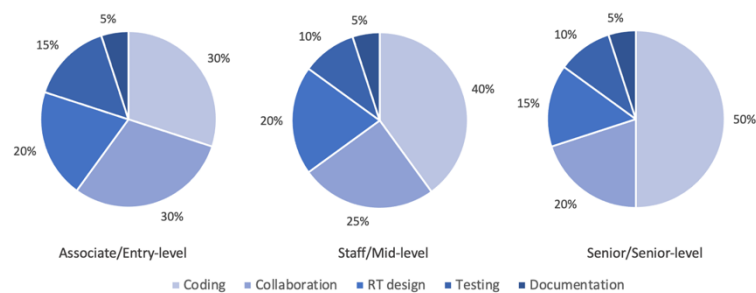
Key ESE duties include coding embedded software for hardware platforms, designing and optimizing real-time embedded software, conducting unit and system testing, debugging, and communicating with Embedded Hardware Engineers (EHEs) and system engineers for product integration. Additionally, ESEs document software design and development processes and stay informed about emerging technologies and industry trends (Figure 1).

Figure 1

Importance and Frequency of ESE's Essential Duties

- Developing code
- Collaboration with EHE, etc.
- Testing and debugging
- Real-time software design
- Documentation
- Staying updated

Tasks like staying updated on industry trends are vital but may not be part of daily workloads. ESEs, from entry-level to senior, share similar workday activities but in varying proportions, reflecting their expertise growth and increasing responsibilities (Figure 2). Further details about career promotion are discussed in the 'Career Path' section.

Figure 2

Daily Tasks and Time Spent

Associate/Entry-level   Staff/Mid-level   Senior/Senior-level

- Coding
- Collaboration
- RT design
- Testing
- Documentation

To excel in essential tasks, ESEs should possess *Knowledge* of relevant programming languages (e.g., C/C++), real-time systems (e.g., RTOS), hardware components (e.g., microcontrollers and communication protocols), programming on demo boards (e.g., MSP, STM32), software testing, debugging, and documentation. They must exhibit *Skills* in software development, real-time design, hardware-software integration, testing, debugging, and essential soft skills like problem-solving, collaboration, teamwork, documentation, and communication. Detailed *Ability* and *Other characteristics* can be found in Table 1. More details on potential engineering techniques involved in specific recruitment practices are summarized in Table 4 in the appendix.

Table 1

KSAOs for Embedded Software Engineers

Knowledge		Skill	
Knowledge	➤ Knowledge of related programming languages ➤ Knowledge of real-time systems ➤ Knowledge of hardware components ➤ Knowledge of programming on demo board ➤ Knowledge of software testing, debugging, and troubleshooting ➤ Knowledge of electrical schematics and documentation	Skill	☐ Skill in embedded software development ☐ Skill in real-time software design ☐ Skill in hardware-software integration ☐ Skill in testing and debugging ☐ Skill in problem-solving ☐ Skill in collaboration and teamwork ☐ Skill in documentation and communication
Ability	● Analytical and critical thinking ● Adaptability and resilience ● Attention to details ● Accountability	Other	✓ Habit of continuous learning ✓ Project mindset and innovation ✓ Teamwork ✓ Time and stress management ✓ Ethical conduct

Criterion, Assessment, and Success Factors

Crucial criteria required for potential success as ESEs can be concluded from the KSAOs above: engineering ability, cognitive ability, problem-solving, interpersonal skills, time management, stress management, teamwork, and adaptability. Corresponding assessment methods for recruitment with acceptable validity, reliability, and cost towards each criterion are listed in Table 2.

Table 2
ESE Performance Criterion, Assessment and Corresponding Validity, Reliability, and Cost

Criterion	Assessment	Validity	Reliability	Cost
Engineering ability	Educational Prerequisite	High	Moderate	Low
	Coding Interview (Hackerrank)	High	High	Low
Cognitive ability	Educational Prerequisite	High	Moderate	Low
	Online Assessment	High	High	Low
Interpersonal skills	HR Interview (Hirevue)	Moderate	Moderate	Moderate
Problem-solving	Managerial Interview	Moderate	Moderate	Moderate
Time & Stress management				
Teamwork				
Adaptability				

As a fundamental model for job analysis, KSAOs aid in summarizing job requirements. To clarify the priority of specific requirements in talent acquisition, success factors for ESE have been categorized as 'Necessary,' 'Desirable,' and 'Nice to Have' in Table 3.
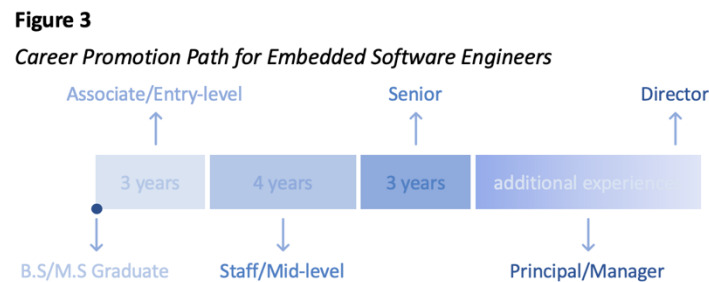
Table 3
Success Factors for Embedded Software Engineers

Necessary	Desirable	Nice to Have
B.S degree in Computer Science/ Electrical Engineering	Proficiency in other Programming Languages	Cross-functional collaboration skills
Proficiency in C/C++	Advanced degree	Excellent verbal and written skills
Proficiency in RTOS	Experience with specific hardware platforms	
Relevant project experience		

Career Path

Embedded Software Engineers (ESEs) face a steep entry threshold, marked by rigorous hard skill prerequisites, including education, project experience, and coding assessments. Higher-level recruitment prioritizes industry experience over certifications. Continuous learning is essential for skill enhancement, and ESE career promotion naturally relies on accumulating valuable experience

Figure 3 outlines the typical promotion path, starting with an associate ESE holding a B.S. or M.S. in Computer

Science or Electrical Engineering. Progressing from associate to senior generally requires 7 to 10 years of experience,

involving increased responsibilities and often leading to project management roles. ESEs with over a decade of

experience may move into managerial roles, overseeing both functional and strategic aspects, and even assume

leadership roles within their organizations.

Figure 3
Career Promotion Path for Embedded Software Engineers

Associate/Entry-level		Senior		Director
3 years	4 years	3 years	additional experience	
B.S/M.S Graduate	Staff/Mid-level		Principal/Manager	

Besides vertical advancement, assessing industry transitions is also vital for ESE's career path. Transitioning within

the same industry is moderately difficult due to shared knowledge and development structures, facilitating skill

transfer. For instance, in the field of new energy vehicle R&D, transitioning between the realms of autonomous

driving systems and intelligent cabin development is expedited by a shared knowledge base within the industry.

Conversely, inter-industry transitions are more challenging due to differences in programming languages, hardware

platforms, and interface protocols. Interviews with experienced SMEs and new graduate entry-level job seekers

indicate that the difficulty of changing industries varies among ESEs at different levels. Entry-level engineers find

such transitions relatively easier, focusing on mastering core skills, resulting in greater mobility and adaptability

during early career stages. Transitioning from the medical device sector to chip development can serve as a

noteworthy example.

Current Demographic and Salary Statistics

LinkedIn is the primary platform for candidate sourcing, according to insights from a senior SE recruiter. Using

LinkedIn People, I collected demographic data for all US ESEs and cross-referenced it with job postings. In Figure

4, you can see that 43% of ESEs are in California, with 26% in the San Francisco Bay area. Figure 5, sourced from

Hired's 2023 State of Software Engineers report, Glassdoor, ZipRecruiter, Comparably, and LinkedIn job postings, illustrates the annual salary distribution among current US ESEs, with an average of $155K. It's worth noting that compensation and benefits for principals, directors, and some senior engineers are highly individualized and negotiable, making them excluded from this figure. Compared to highly sought-after backend engineers, demand for ESEs is lower, but their salaries and demand remain stable. (Hired, 2023) This stability is due to their crucial role in advanced manufacturing, characterized by stringent hardware-software integration requirements. While demand for ESEs is not expected to experience sudden spikes, it is a role with enduring value.

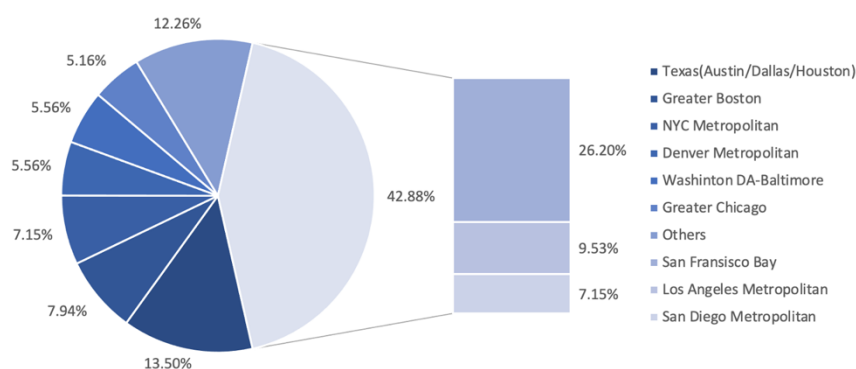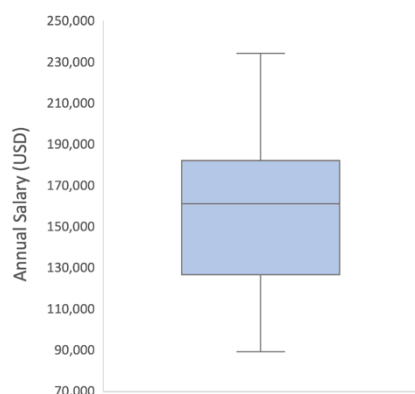**Figure 4**

Demographic Statistics of Current ESEs in the USA

Figure 5

Annual Salary(USD) of ESEs in the USA

Insights

Conducting this Job Analysis enabled me to apply my data integration and interpretation skills to the workplace. My research about ESE's career path uncovers a universal logic behind career transitions at various angles and levels.
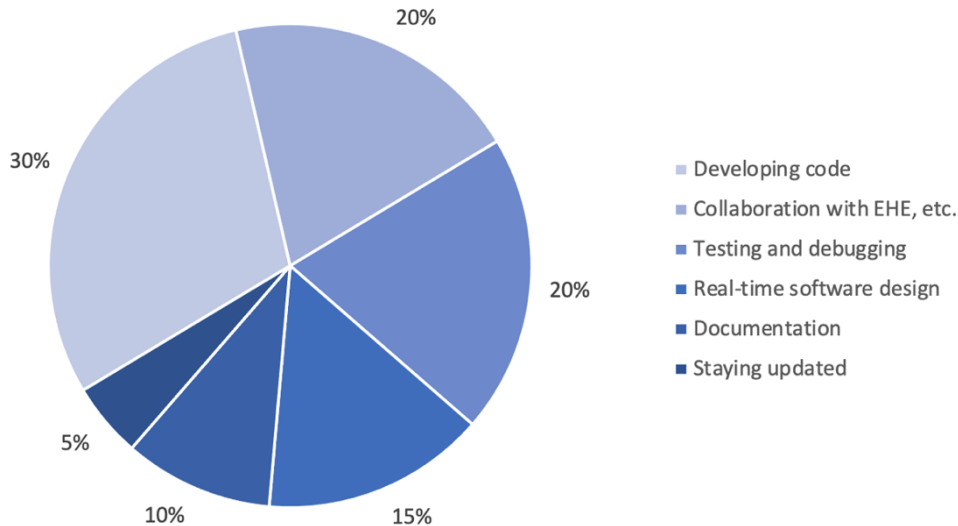
During a discussion with a previous software engineer recruitment intern at Byte Dance, I realized that in real-world recruitment, HR faces challenges in distinguishing technical details, like the numerous algorithms and protocols related to embedded software engineering, which can hamper their efficiency. The difficulty in job analysis also lies in expressing professional terms in an HR-friendly way. Thus, interviews with incumbents and job seekers are efficient in alleviating professional barriers, while LinkedIn profiles can instruct the career path and frequency of transactions. In practice, referring to previous job analysis is just the first step, HR should prioritize communication with the hiring department to pinpoint their exact requirements.
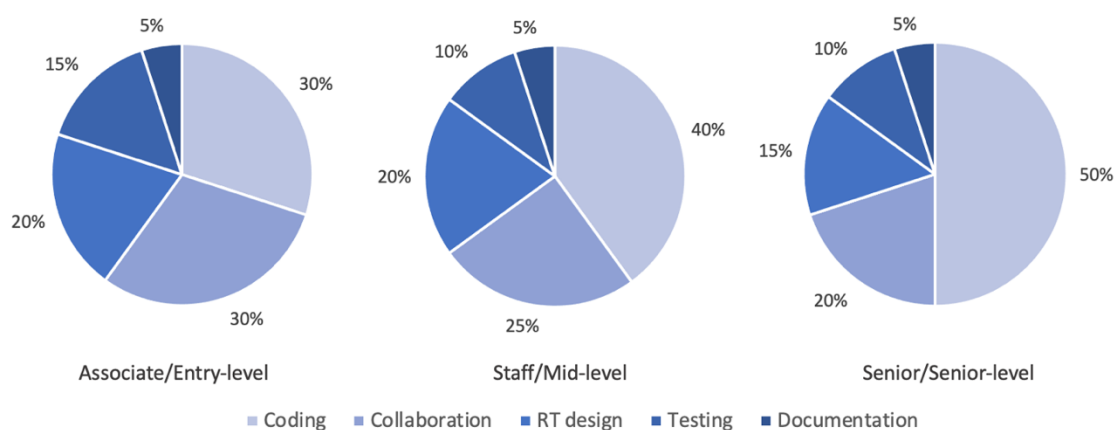
Appendix

Figure

Figure 1

Importance and Frequency of ESE's Essential Duties

20%

30%

20%

5%

10%

15%

- Developing code
- Collaboration with EHE, etc.
- Testing and debugging
- Real-time software design
- Documentation
- Staying updated

Note. The general proportion of embedded software engineers' duties at all levels. Embedded software engineer as a technique domain position, the frequency of essential duties positively correlated with its importance, in which developing code, collaboration with other teams, testing and debugging, and RTOS account for 85% of the workload. From interviews with incumbent SMEs and EmbeddedRealted.com (https://www.embeddedrelated.com/).
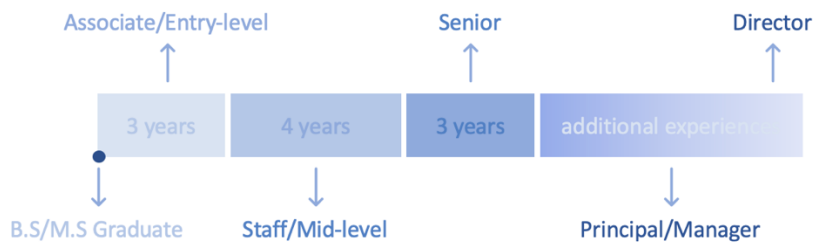
Figure 2

Daily Tasks and Time Spent

Associate/Entry-level: 5%, 15%, 20%, 30%, 30%, 20%

Staff/Mid-level: 5%, 10%, 40%, 25%, 20%, 15%

Senior/Senior-level: 5%, 10%, 50%, 20%, 15%

- Coding
- Collaboration
- RT design
- Testing
- Documentation

Note. Embedded software engineers' workday tasks from entry-level to senior represent the major and crucial situations, they mainly focus on software development with few managerial tasks. Generally, time spent on coding increases alongside promotion among these levels. From interviews with and observation on incumbent SMEs' and new graduates' daily lives, posted Job Description from Meta, Apple, etc. on LinkedIn (https://www.linkedin.com/jobs/search/?currentJobId=3703154219&keywords=embedded%20software%20engineer&origin=SWITCH_SEARCH_VERTICAL).
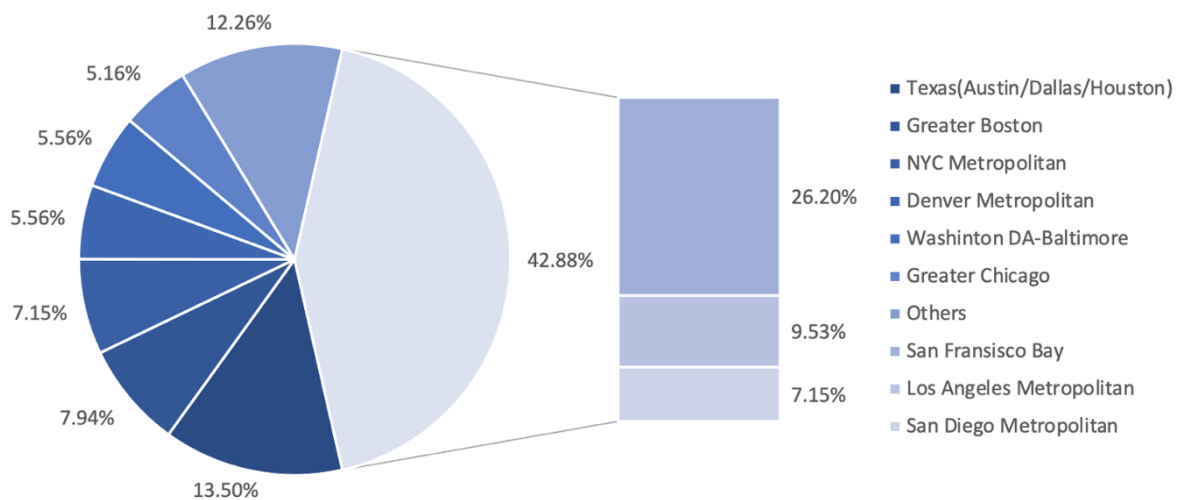
Figure 3

Career Promotion Path for Embedded Software Engineers

Note. Embedded software engineer's typical career promotion timeline. From interviews with SMEs, posted Job Descriptions of different levels on LinkedIn, O*NET (https://www.onetonline.org/link/summary/15-1252.00).

Figure 4

Demographic Statistics of Current ESEs in the USA

Note. Demographic statistics of incumbent embedded software engineers in the USA on September 2023. California accounts for approximately 43% of the positions, with specifics dispersed in the San Francisco Bay area, Los Angeles Metropolitan area, and San Diego Metropolitan area. Statistics were collected and calculated from LinkedIn People and cross-checked with the demographic distribution of job posting numbers in the USA from LinkedIn Jobs.

Figure 5

Annual Salary(USD) of ESEs in the USA
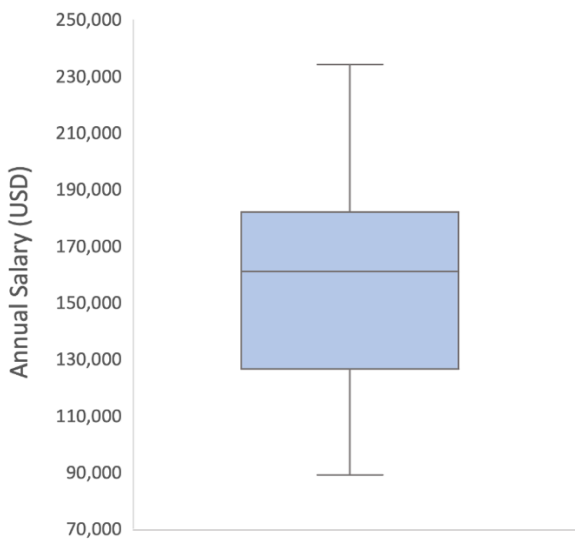
Note. The average annual salary (USD) for the majority of embedded software engineers in the USA is about 155K, total range is from 89K to 243K(Meta). Compensation and benefits for principals, directors, and some senior engineers are highly individualized and negotiable, making them excluded from this figure. From posted jobs' salary range on LinkedIn, Hired (2023), Glassdoor (https://www.glassdoor.com/Salaries/entry-level-embedded-software-engineer-salary-SRCH_KO0,38.htm), ZipRecruiter (https://www.ziprecruiter.com/Salaries/Embedded-Software-Engineer-Salary), Comparably (https://www.comparably.com/salaries/salaries-for-embedded-software-engineer).

Tables

Table 1

KSAOs for Embedded Software Engineers

Knowledge	- Knowledge of related programming languages - Knowledge of real-time systems - Knowledge of hardware components - Knowledge of programming on demo board - Knowledge of software testing, debugging, and troubleshooting - Knowledge of electrical schematics and documentation	Skill	- Skill in embedded software development - Skill in real-time software design - Skill in hardware-software integration - Skill in testing and debugging - Skill in problem-solving - Skill in collaboration and teamwork - Skill in documentation and communication
Ability	- Analytical and critical thinking - Adaptability and resilience - Attention to details - Accountability	Other	- Habit of continuous learning - Project mindset and innovation - Teamwork - Time and stress management - Ethical conduct

Note. Typical KSAOs for embedded software engineers. From posted Job Descriptions, LinkedIn People's profiles, and interviews with SMEs.

Table 2

ESE Performance Criterion, Assessment and Corresponding Validity, Reliability, and Cost

Criterion	Assessment	Validity	Reliability	Cost
Engineering ability	Educational Prerequisite	High	Moderate	Low
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Interpersonal skills	HR Interview (Hirevue)	Moderate	Moderate	Moderate
Problem-solving	Managerial Interview	Moderate	Moderate	Moderate
Time & Stress management				
Teamwork				
Adaptability				

Note. Crucial criteria for embedded software engineers' potential success, assessment methods used in the hiring process, and corresponding validity, reliability, and cost. From Muchinsky, P. M. & Howes, S. S. (2019) p.135.

Table 3

Success Factors for Embedded Software Engineers

Necessary	Desirable	Nice to Have
B.S degree in Computer Science/ Electrical Engineering	Proficiency in other Programming Languages	Cross-functional collaboration skills
Proficiency in C/C++	Advanced degree	Excellent verbal and written skills
Proficiency in RTOS	Experience with specific hardware platforms	
Relevant project experience		

Note. Success factors for embedded software engineers, categorized as 'Necessary', 'Desirable', and 'Nice to Have'. From interviews with SMEs, and posted Job Descriptions' minimum to preferred requirements

Table 4

Detailed KSAOs for ESE in Specific Recruitment Practices

Knowledge	**Knowledge of related programming languages**
	Knowledge of C/C++, understanding of multi-threading, data structure, and algorithms
	Knowledge of other languages may be required by particular companies (e.g., Python, Java/JavaScript, Assembly, Rust, etc.)
	Knowledge of real-time systems
	Knowledge of real-time operating systems (RTOS)
	Knowledge of FreeRTOS, Linux, ROS (Robot Operating System), etc. may be required by particular companies
	Knowledge of hardware components
	Knowledge of hardware components and interfaces, including microcontrollers, sensors, and communication protocols (e.g., SPI, QSPI, I^2C, UART, USART, TCP/IP, Ethernet, Bluetooth, etc.)
	Knowledge of programming on demo board
	Knowledge of programming on development boards (e.g., TI MSP, STM32, Raspberry Pi, Arduino, etc.)
	Knowledge of software testing, debugging, and troubleshooting
	Proficiency in testing techniques, debugging tools, and troubleshooting methods for ensuring software reliability
	Knowledge of electrical schematics and documentation
	Knowledge of electronic schematics and documentation including software design, code comments, and technical reports
Skill	**Skill in embedded software development**
	Proficient in developing software for embedded systems, with a focus on efficiency, reliability, and resource optimization
	Skill in real-time software design
	Skill in designing and implementing real-time embedded software that meets strict timing constraints
	Skill in hardware-software integration
	Skill in integrating software with hardware components and ensuring compatibility
	Skill in testing and debugging
	Strong testing and debugging skills to identify and resolve software defects efficiently
	Skill in problem-solving
	Strong problem-solving skills to address software-related challenges and unexpected issues
	Skill in collaboration and teamwork
	Ability to collaborate effectively with cross-functional teams, including hardware engineers, system engineers, quality assurance engineers, etc.
	Skill in documentation and communication
	Effective documentation skills and clear communication of technical information to team members and stakeholders

Ability	**Analytical and critical thinking**
	Ability to analyze complex software-hardware interactions and identify optimization opportunities
	Adaptability and resilience
	Ability to adapt to evolving technologies and changing project requirements and work under pressure
	Attention to details
	Ability to detect meticulous approach to code quality, documentation, and testing to ensure software reliability
	Accountability
	Ability to admit mistakes
Other characteristics	**Habit of continuous learning**
	Commitment to staying updated on emerging technologies, tools, and industry trends
	Project mindset and innovation
	Willingness to explore innovative solutions and technologies to enhance practical software development processes
	Teamwork
	Effective teamwork and collaboration with cross-functional teams to achieve project goals
	Time and stress management
	Efficient time management to meet project deadlines and milestones
	Ethical conduct
	Maintaining high ethical standards, confidentiality, and professionalism

Note. KSAOs for embedded software engineers with detailed explanations and specific requirements in actual recruitment process. From interviews with SMEs, and posted positions from representative companies, such as Meta, Google, Apple, Amazon, etc.

Interview Outline

1. Essential Duties: What are the fundamental tasks that embedded software engineers need to handle in a typical workday? Which tasks seem to be the most significant in your workload?

2. Duties at Different Levels: Let's talk about the responsibilities of embedded software engineers at different career stages. Can you share how the importance of essential duties changes based on your experience?

3. Daily Tasks: Walk me through a typical day for embedded software engineers, as an entry-level/senior. Do you mostly focus on software development, or are there managerial tasks you also need to pay attention to?

4. Coding Focus: As engineers move up the career ladder, how does the time they spend on coding evolve? Do coding responsibilities take center stage as they progress?

5. Career Promotion: Can you provide an overview of how a typical embedded software engineer's career progress? What are the key milestones and changes in their roles over time?

6. KSAOs Overview: Let's talk about the essential Knowledge, Skills, Abilities, and Other characteristics (KSAOs) expected from embedded software engineers. What specific expertise is crucial in this field?

7. Success Factors: What would you say are the factors that contribute to success for embedded software engineers? If we were to categorize these factors as 'Necessary,' 'Desirable,' and 'Nice to Have,' how would you classify them?

8. Collaboration Importance: Collaboration is often vital in any role. How important is it for embedded software engineers, will the ability to collaborate impact their overall success?

9. Continuous Learning: Given the fast-paced nature of the embedded systems field, based on your experience or observation, how crucial is the commitment to continuous learning and staying updated on emerging technologies for career growth and job performance?

Example of Job Description

Embedded Software Engineer

Location: Sunnyvale, CA (On-site)
Company: Meta

About the job

Meta Reality Labs focuses on building technology to help people connect through Augmented Reality (AR) and Virtual Reality (VR). Our embedded software will enable AR and VR devices where our real and virtual world will mix and match throughout the day. We believe the way to achieve our goals is to look at the entire stack, from custom ASICs and new technologies, firmware, algorithms, OS, to user experiences. As an Embedded Software Engineer, you will architect, design, build and test embedded firmware systems for future AR, VR, or New Technology Teams. In this role, you are expected to participate in the definition of architecture and implementation of designs in both prototype and shipping consumer products as well as demonstrate good development practices and seamless collaboration. Our teams deliver all embedded software from low-level device drivers, to computer vision, to machine learning algorithms. Engineering for Reality Labs device systems spans multiple target classes, requiring deep collaboration across engineering disciplines (electrical, mechanical, algorithms, user experience, silicon architects, and software) and directly impacting user immersion. Our engineers quickly solve problems, generate big ideas, work in new technology areas, drive concepts into prototypes, and envision how those prototypes transition to high-volume consumer products. You will join a world-class team of experts exploring new concepts through rapid prototyping leading to shipping products.

Embedded Software Engineer Responsibilities

- Analyze, design, develop, and debug firmware for a wide variety of AR and VR consumer devices, including novel sensing and imaging systems, haptic devices, and audio prototypes
- Collaborate closely in a team environment with silicon architects, hardware designers, OS team, and algorithm and model development teams
- Support all phases of hardware development - including early architecture requirements definition for custom silicon, firmware architecture, implementation, simulation, FPGA debug, chip bring up and support systems and software teams on algorithm development on validated systems
- Understand and implement power-management, boot loaders, scheduling, inter-processor communication and firmware / system interfaces on RTOS and/or bare-metal environments

Minimum Qualifications

- B.S. degree in Computer Science or Electrical Engineering or equivalent experience
- 4+ years of experience in embedded software development
- Experience with embedded software design and programming in C/C++ for development, debugging, testing and performance analysis
- Experience in understanding hardware, clock-level issues, bridges, delays, interrupts, clock gating, polling etc.
- Experience building software for complex embedded systems or custom SoCs
- Experience partnering and/or collaborating across multiple teams

Preferred Qualifications

- Experience with compression, camera and video pipelines, or encoding technologies such as H.264
- Hands-on coding experience with peripherals such as UART, SPI, CSI-2, i2c, GPIO, USB
- Experience with wireless and wired communication protocols ,TCP/IP, Ethernet, Bluetooth and 802.11
- Experience across topics including computer graphics, computer vision, or machine learning
- Experience with silicon, device manufacturing, and low-power SoCs
- Experience with active power management or power optimizations
- Experience with prototyping or pre-silicon environments (FPGAs, simulation, or emulation)
- Experience with lab instrumentation like oscilloscope, logic/protocol analyzers for debugging embedded systems at HW level
- Experience with embedded DSP, CPU, and GPU architectures
- Experience developing with modern Real Time Operating Systems

About Meta

Meta builds technologies that help people connect, find communities, and grow businesses. When Facebook launched in 2004, it changed the way people connect. Apps like Messenger, Instagram and WhatsApp further empowered billions around the world. Now, Meta is moving beyond 2D screens toward immersive experiences like augmented and virtual reality to help build the next evolution in social technology. People who choose to build their careers by building with us at Meta help shape a future that will take us beyond what digital connection makes possible today—beyond the constraints of screens, the limits of distance, and even the rules of physics.

Meta is proud to be an Equal Employment Opportunity and Affirmative Action employer. We do not discriminate based upon race, religion, color, national origin, sex (including pregnancy, childbirth, or related medical conditions), sexual orientation, gender, gender identity, gender expression, transgender status, sexual stereotypes, age, status as a protected veteran, status as an individual with a disability, or other applicable legally protected characteristics. We also consider qualified applicants with criminal histories, consistent with applicable federal, state and local law. Meta participates in the E-Verify program in certain locations, as required by law. Please note that Meta may leverage artificial intelligence and machine learning technologies in connection with applications for employment.

Meta is committed to providing reasonable accommodations for candidates with disabilities in our recruiting process. If you need any assistance or accommodations due to a disability, please let us know at accommodations-ext@fb.com.

Pay range in Sunnyvale, CA

Exact compensation may vary based on skills, experience, and location.

Base salary

$143,000/yr - $204,000/yr

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